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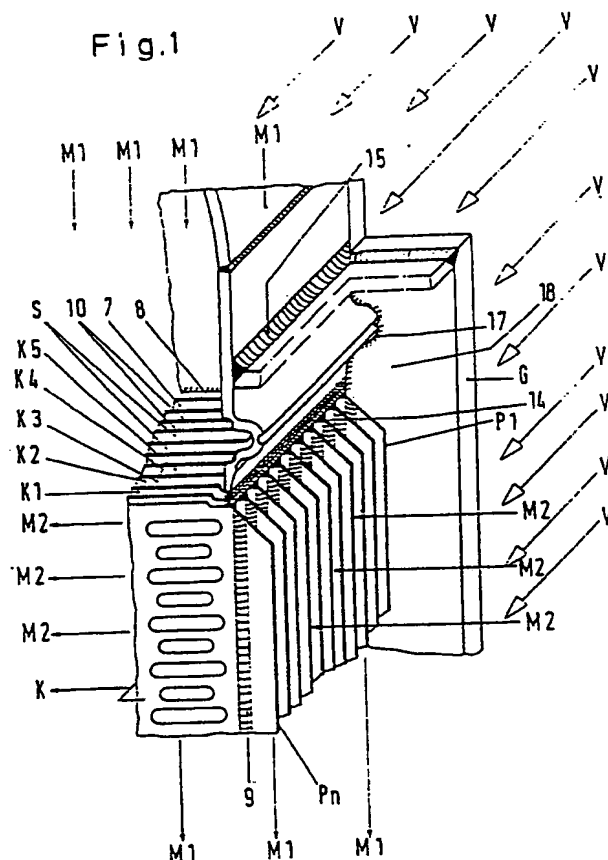
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(54) Producing welded plate heat exchangers,  
 more particularly cross-flow plate heat exchangers

(57) The method comprises joining together discrete plates (K1, K2, K3, K4, K5), which have regular impressions, on their unimpressed edges by roll seams (9) to form plate pairs bounding gap-like flow channels (5) for a first heat-exchanging medium (M1). The stacked-up plate pairs are effective by way of their surfaces near one another to bound tubular flow channels for a second heat-exchanging medium (M2) and are rigidly joined together by adjacent plates of two plate pairs being joined together to form a stack by means of fillet seams (10) extending perpendicularly to the roll seams, the stack having for fluidwise separation of the two media, corner seams (14) disposed on its four connection edges extending perpendicularly to the other seams. After the roll seams (9) have been produced the plate pairs joined together to form a loose stack are subjected to a surface load (V) in the form of mechanically or thermally or hydraulically produced preloading or biasing forces which correspond approximately to loads experienced in operation and which are oppositely directed to such loads and which continue to be applied until the fillet seams (10) and the corner seams (14) - have been made.



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Fig.1

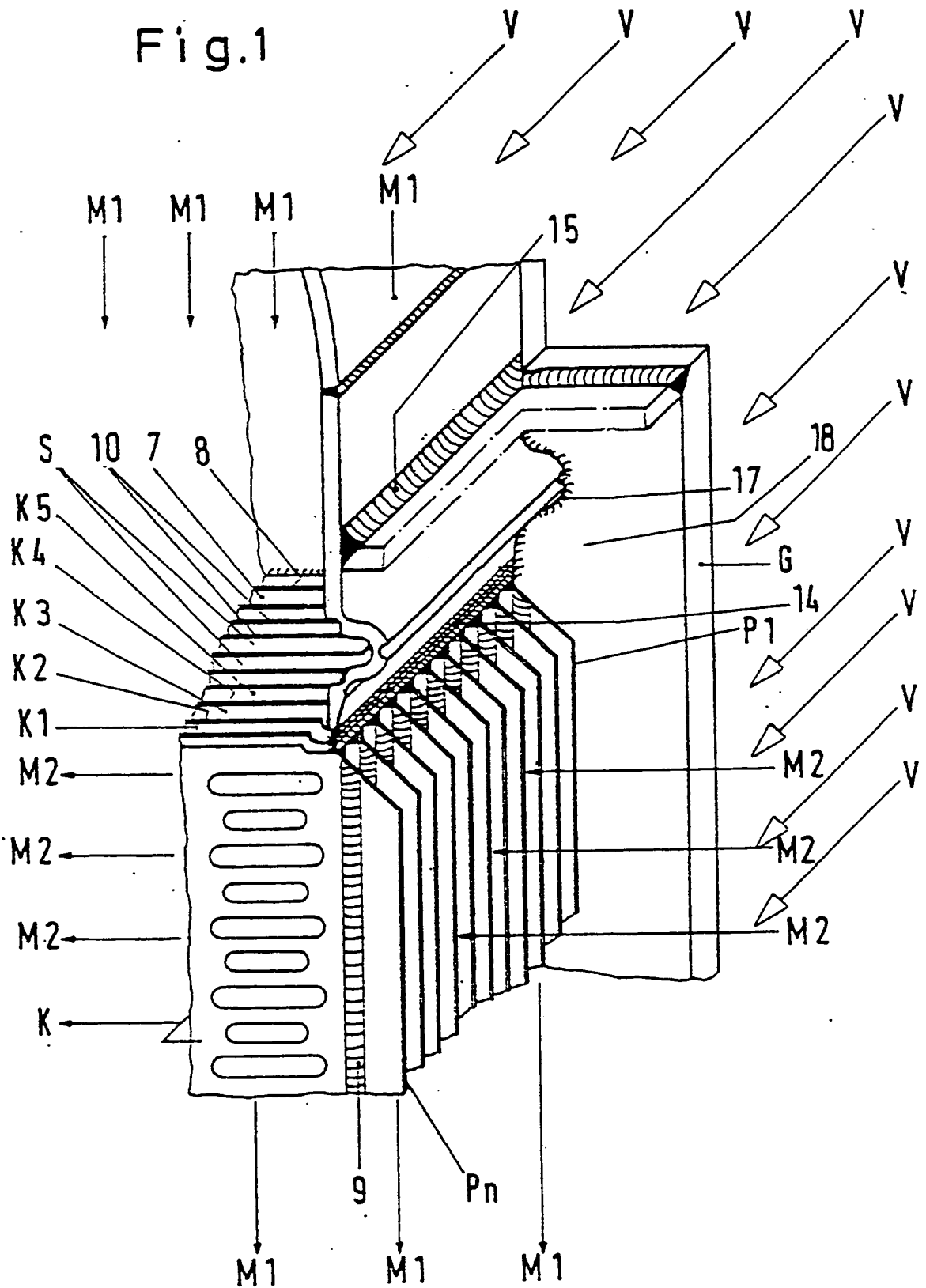
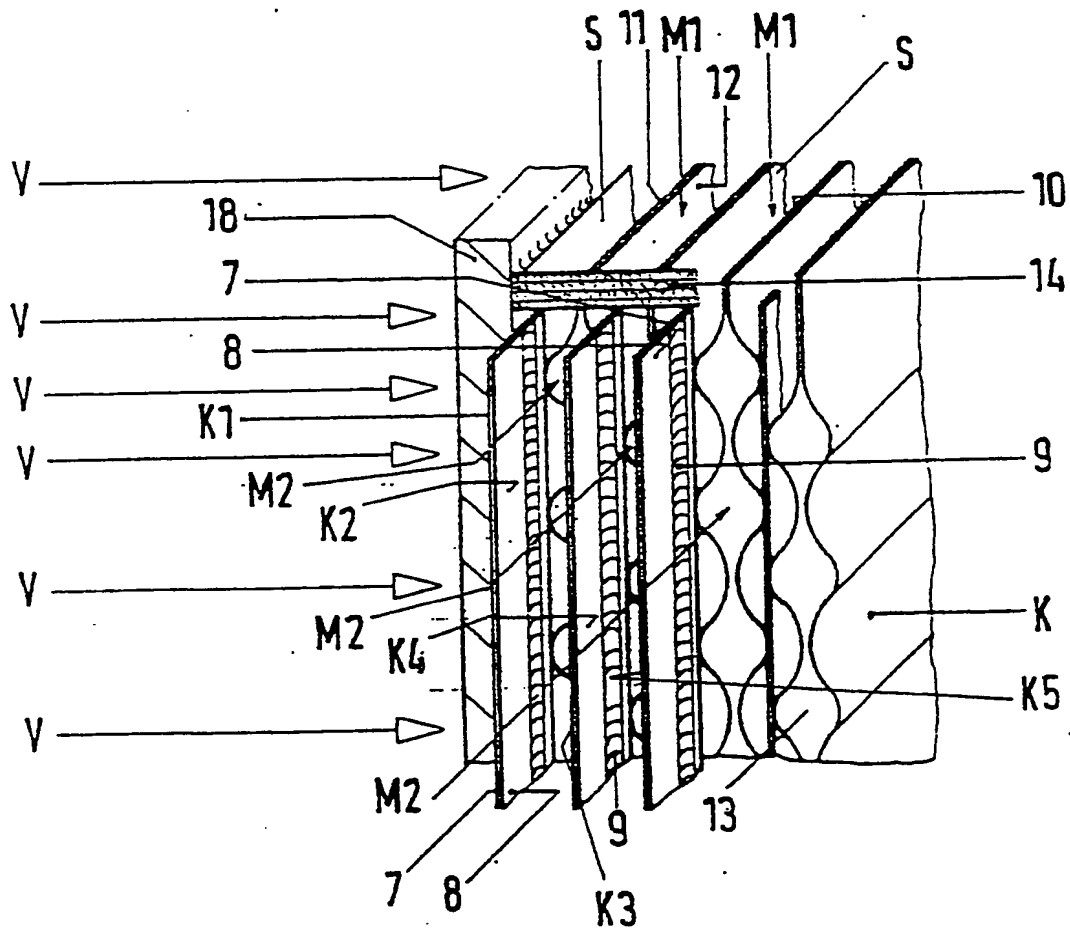


Fig.2



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Fig.3

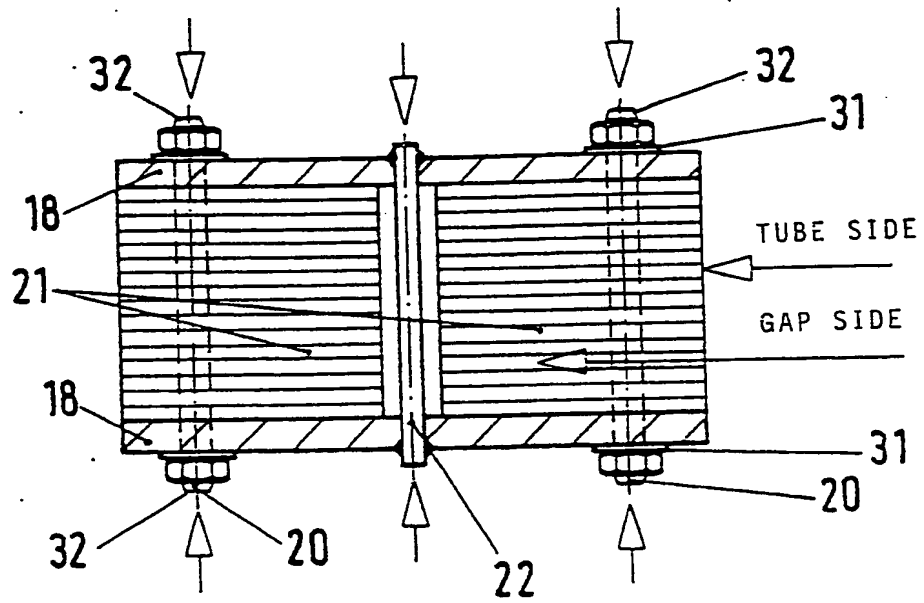


Fig.4

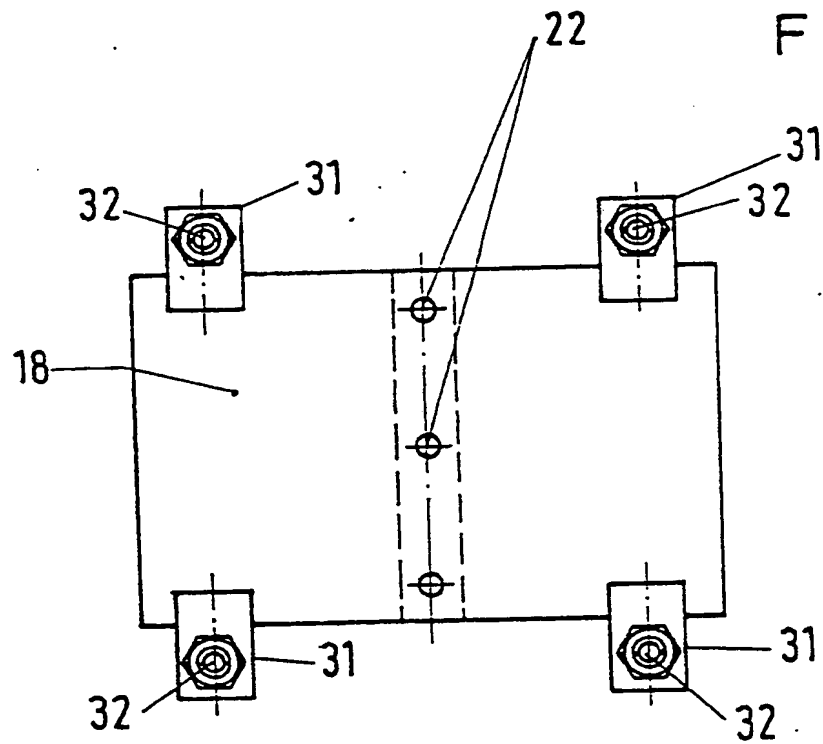


Fig.5

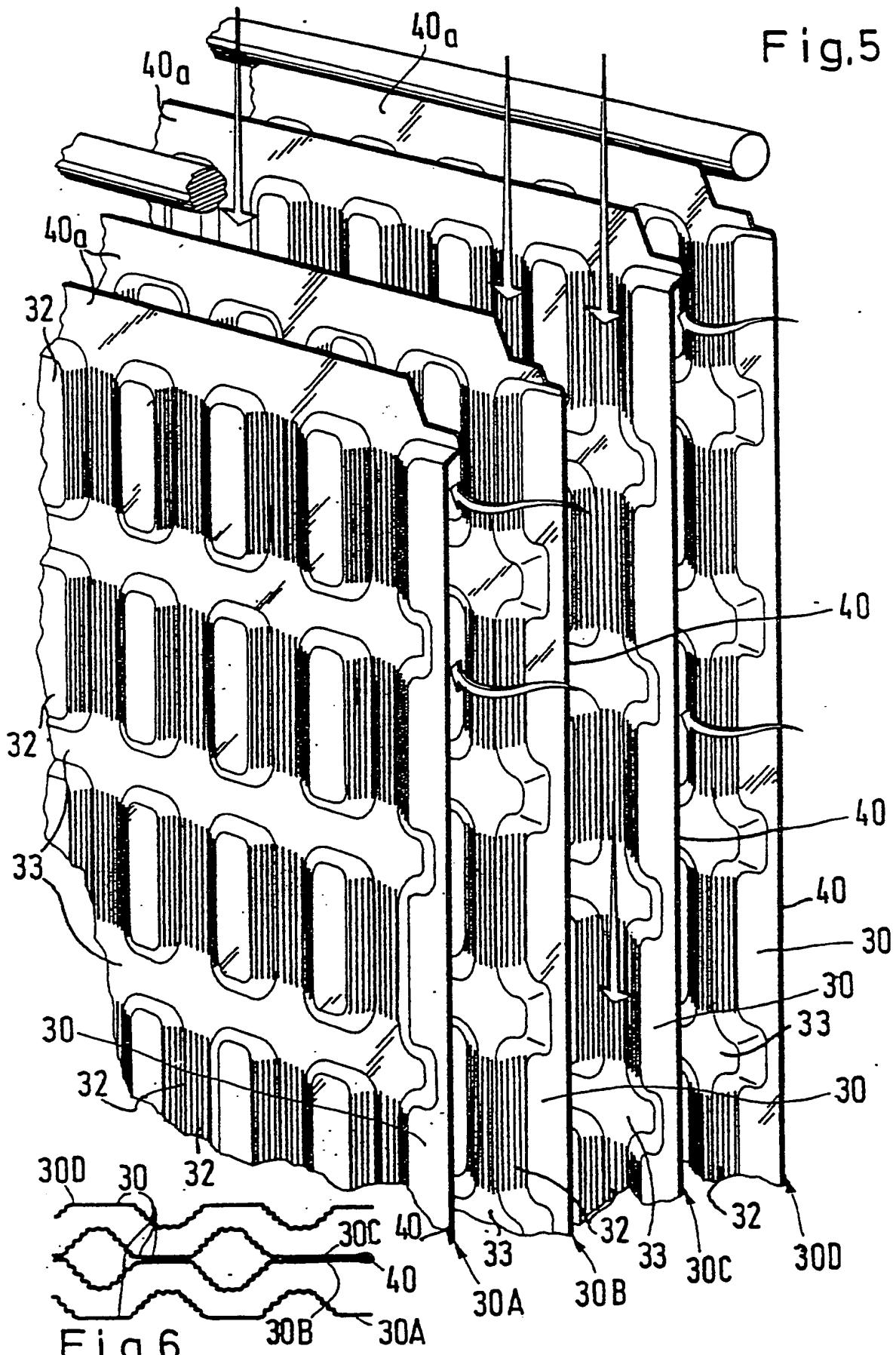
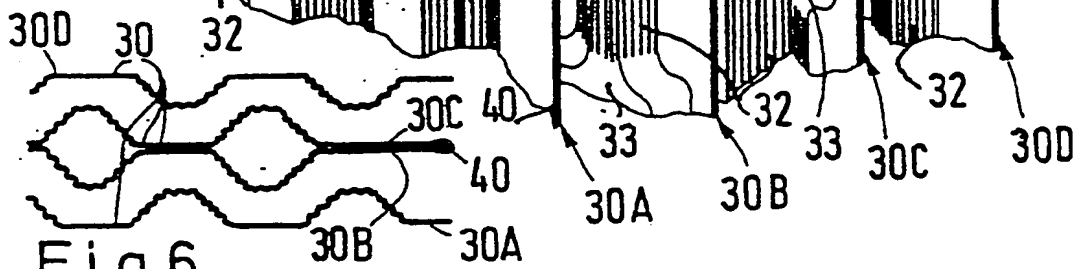


Fig.6



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A METHOD OF PRODUCING WELDED PLATE HEAT EXCHANGERS, MORE  
PARTICULARLY CROSS-FLOW PLATE HEAT EXCHANGERS

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The invention relates to a method of producing welded plate heat exchangers, more particularly cross-flow plate heat exchangers, as set out in the preamble of claim 1.

In plate heat exchangers whose core comprises a number of contiguous wavy discrete plates, in order to separate the flow channels for the two heat-exchanging media it is known for the discrete plates either to be sealed at their junctions with one another with sealing means of various kinds and to be firmly held together, for example, by threaded assembly rods (cf. GB-PS 1 034 466).

It is also known (cf. DE-PS 1 601 215) for the discrete plates of such a heat exchanger to be soldered or welded in their junction zones.

To this end, the discrete plate elements are pressed to form a wavy structure in order to ensure that the conditions of heat and flow are optimal for heat exchange. The wavy structure leads to flow alterations at continuous intervals, with the effect of considerably increasing turbulence, and also considerably enlarges the area used for heat exchange. Also, the wavy structure gives the exchanger plates the strength necessary to withstand static and dynamic loads before and more particularly in operation. The rigidity of the corrugated plates in the group of heat exchanger plates also depends upon the load capacity in the contact zones between the discrete contiguous corrugations, distortions of which cause stresses.

Other loads acting on the heat exchanger core include internal pressures emanating from the heat-exchanging media - i.e., the pressure differences between the two flow channels, heat shocks and other transient phenomena associated with the start-up and stoppage of heat exchangers of this kind in process plants, heat stressing, external forces and moments and other additional loadings arising from unsteady operation.

Stress conditions giving an overall complex physical stress area arise in the various zones of the stack of plates or such a pressure member in dependence upon the strength of materials, plate thickness, depth of impression, width of impressions and of

plate pockets, pocket length and the number of plates disposed one above another - i.e., upon the whole of the geometric configuration.

There are two main characteristic parameters - i.e., the maximum permissible working pressure and the working temperature - which determine the range of use of such a heat exchanger. These two parameters are closely interrelated, their values being inversely proportional to one another - i.e., the permissible working pressure decreases as the temperature difference between room temperature and working temperature increases.

The usual reason for this result is that permissible stresses decrease as the temperatures of the plate materials used increase.

When resilient seals are used to seal off the discrete plate elements from one another, it becomes impossible to fully use the mechanical strength of the wavy plates. Instead, the main consideration determining the strength of such plate stacks is the pressure and temperature strength of the sealing materials; also, the same have a relatively short working life in the operating conditions of the heat exchangers and have to be replaced. Also, the sealing tightness of such junctions or joints is very unsatisfactory, more particularly



when the heat-exchanging media have aggressive properties. The strength and sealing tightness of exchanger cores soldered by way of the plate edges depends mainly upon the strength and thickness of the soldered joints which, in the light of the strength of welded joints at the relatively high working temperatures, are far less than the mechanical strength of the wavy plate structures.

When the connecting edges of the wavy plates are welded over a width safe for the structure, strong and simultaneously sealing-tight welded joints of this kind cease to be weak spots in the overall strength pattern; instead, experience shows that permissible loading is determined by the structure as such.

For reasons of environmental protection and energy saving, it is becoming increasingly necessary to use heat exchangers even in process plants working in extreme conditions, and so the requirements made on heat exchangers are also becoming increasingly stringent.

It is also very important in heat exchanger construction to achieve high power density - i.e., an optimal relationship between size of construction and heat exchanger performance - and a satisfactory power-to-weight ratio. These high specific heat performance requirements depend to a large extent upon the media

pressures and temperatures used - i.e., permissible - in operation.

It is therefore the object of the invention to propose steps enabling welded heat exchanger structures to be improved so that their strength can be increased and, therefore, their range of use widened without additional expenditure on material and construction.

The invention solves this problem by the operative features of claim 1.

According to the invention, therefore, in the production of the heat exchanger stack, after the first weld seam has been produced in the form of a roll seam, so that pairs of plates having gap-like flow channels are formed, the pairs of plate elements are joined together to form a loose stack and have applied to them preloading or biasing forces, in the form of a uniform surface load exerted oppositely to the loads occurring in operation, until the second and third weld seams have been made in the form of fillet seams and corner seams. The method according to the invention therefore makes it possible to produce a resilient deformation of the plate elements despite a substantially dot-like contact between the pressed profiles of every two plate elements, such deformation leading during welding operations to a

very definite bond in the structure of the plate stack, thus increasing the load capacity of the heat exchanger.

According to the invention, as surface load the plate elements in the stack experience a load in dependence upon the subsequent working pressure in the plate elements (maximum pressure at different pressure on the tube side and the gap side), the load preferably being from 1 to 15 kg/cm<sup>2</sup> in dependence upon the from 0.5 to 1.0 mm wall thickness and upon the from 13.2 to 4.5 mm depth of impression of the approximately 18 mm long impressions in the plate elements - i.e., in dependence upon the geometric configuration and the permissible working pressure of the plate exchanger structure.

Advantageously, to transfer the biasing or preloading forces to the stack of plates the surface load is applied to the plate elements of the stack by way of external plates having a configuration corresponding to plate element configuration; the outer walls of the pressure vessel used to receive the heat exchanger stack can be used as load-applying external plates.

The surface load is produced mechanically or thermally or hydraulically in a predeterminable magnitude; when the plate elements of the stack are of substantial size, additional anchor means (studs, profilings or the like) are welded in between the

outer walls before the surface load is applied (pressure preloading) and are effective as tie rods when the pressure preloading is decreased.

When the surface load is applied thermally, the rods retaining the plate groups during welding are heated before insertion in the plate groups so that the cooling pins shrink-on the plate groups before the next welding is performed.

In a development of the invention a plate elements is provided wherein the wall thickness of the plate elements is from 0.5 to 1.1 mm, the depth of impression of the profilings is from 3.2 to 7.0 mm and the length of impression of the profilings is from 10 to 20 mm; the roll seams opposite one another and the transverse seams correspond in their widths to the widths of the plate elements to be joined together, the widths preferably being of from 2 to 4 mm corresponding to a plate element width of from 250 to 400 mm.

The invention will be described hereinafter with reference to the drawings which diagrammatically illustrate an embodiment and in which in detail:

Fig. 1 is a perspective view showing a part of a heat exchanger according to the invention with the front side wall removed.

Fig. 2 is another perspective view of a part of the heat exchanger core of Fig. 1 looking in the direction of arrows M2 of Fig. 1;

Fig. 3 is a section through an apparatus for the practice of the method of producing a welded plate heat exchanger according to the invention;

Fig. 4 is a plan view of the apparatus of Fig. 3;

Fig. 5 is a view to an enlarged scale of a number of plate elements, and

Fig. 6 is a partial section through the plate elements of Fig. 5.

A heat exchanger core comprises a number of discrete thin-walled honeycomb-shaped plate elements or plates K1, K2, K3, K4, K5 etc.; in all cases two individual plates K2, K3 or K4 and K5, placed on one another in laterally inverted form are joined together on their opposite edge zones 7, 8 by first weld seams 9, which are roll seams, to form plate pairs P1 to Pn, the discrete plates each forming by way of their corresponding shapings a flow gap S for a heat-yielding medium M1. Each plate pair P2, P3 is rigidly connected to the adjacent plate pair P4, P5 by opposite second seams 10, which are fillet seams or transverse seams and

extend on the plate pair edges and perpendicularly to the first seams 9 - i.e., roll seams - i.e., the fillet seams 10 rigidly interconnect the adjacent plates K1, K2 and K3, K4 of any one pair by way of their opposite edge zones 11, 12; the plates K1, K2 and K3, K4 which are near one another form by their corresponding shapings flow tubes 13 (see Fig. 2) for a heat-receiving medium M2. Consequently, and as Figs. 5 and 6 show, each heat exchanger plate K is a pressed plate 30 and has as shaping or profiling uniformly disposed grooves 32, 33 aligned in modular fashion lengthwise and transversely. As already stated, the heat exchanger plates are welded together in pairs in a stack one upon another relatively to their grooves 32 and are welded together by the roll seam on their transverse edges 40. The grooves 33 of the adjacent plates therefore bound the gap-like channels S. When two such plate pairs are stacked one upon another in laterally inverted form, the grooves 32 which extend in the other direction form the tube-like channels 13 disposed between the outer plates 30 of such a plate pair. Consequently, the adjacent tube-like channels 13 arise in one direction and the adjacent gap-like channels S arise in the direction which is transverse of the said one direction, and so the heat-exchanging media M1, M2 can flow in cross-current relatively to one another.

There therefore arises a plate group/heat exchanger core of a predetermined height in accordance with the required heat

exchanger performance and the group is consolidated in the direction of stack height - i.e., perpendicularly to both the roll seams and transverse seams - by four corner build-up seams 14 at the corners of the group. The seams 14 are also effective to connect the exchanger core to exchanger casing 18 and to seal the flow channels off from one another.

After the roll seams 9 have been applied the loosely stacked plate group comprising the plate pairs P1 to Pn has applied to it by way of plate outside surfaces 18 biasing or preloading forces V chosen in accordance with the likely working pressures. Such forces can be applied in known manner hydraulically or thermally or mechanically and adjustably. The adjustable surface loading can be applied by way of outer plates of a configuration corresponding to the configuration of the plate elements.

An appropriate apparatus for this purpose is illustrated in Figs. 3 and 4.

In Figs. 3 and 4 the outer plates 18 of the heat exchanger are disposed between clips 31 which screwthreaded pins 32 press together adjustably to produce the surface loading. The plate groups 21 are disposed between the outer plates. The biasing or preloading forces V are therefore produced by a definite tightening of the tie rod or stud fastenings.

The forces V can be produced by way of tie rods 22 which are welded when heated into the outer plates before the plate element pairs are welded together to form a stack. The tie rods remain in position whereas the studs or pins or the like 32 are removed after completion of the welded joints.

The forces V are applied until the transverse seams or fillet seams 10 and corner seams 14 have been made. The direction in which the forces V are operative can be gathered from Figs. 1 and 2, where they act on the outer individual casing wall 18 on one side.

Fig. 3 shows places 21, 22 where the mechanically or hydraulically or thermally applied biasing or tie rod forces can be applied.



C L A I M S

1. A method of producing welded plate heat exchangers whose plate elements have regular impressions and are joined together by roll seams at their unimpressed edges to form plate pairs bounding gap-side apertures, the plate pairs being joined together to form a stack by fillet seams interconnecting the end joints of the near-together plate elements of two adjacent plate pairs, the same bounding tube-side openings, the gap-side and tube-side apertures of the stack being disposed at an angle to one another, corner weld seams being applied to the stack corners perpendicularly to the roll seams and fillet seams for fluidwise separation between the gap-side and tube-side apertures, characterised in that after the roll seams have been made the plate element pairs joined together to form a stack have a definite surface load applied to them uniformly and the near-together plate elements of two plate pairs are joined together by the end-joint fillet seams and the corner seams are applied and

after termination of the welding steps the surface load is removed from the stack.

2. A method according to claim 1, characterised in that as surface load the plate elements in the stack experience a load in dependence upon the subsequent working pressure in the plate elements (maximum pressure at different pressure on the tube side and the gap side), the load preferably being from 1 to 15 kg/cm<sup>2</sup> in dependence upon the from 0.5 to 1.0 mm wall thickness and upon the from 13.2 to 4.5 mm depth of impression of the approximately 18 mm long impressions in the plate elements.

3. A method according to claim 1 or 2, characterised in that the surface load is applied to the plate elements of the stack by way of external plates having a configuration corresponding to plate element configuration.

4. A method according to claim 1 or 2, characterised in that the outer walls of the pressure vessel used to receive the heat exchanger stack are used as load-applying external plates.

5. A method according to any of Claims 1 - 4, characterized in that the surface load is produced mechanically or thermally or hydraulically in a predeterminable magnitude.

6. A method according to claim 1 or 2, characterised in that when the plate elements of the stack are of substantial size, additional anchor means are welded in between the outer walls before the surface load is applied (pressure preloading) and are effective as tie rods when the pressure preloading is decreased.

7. A plate element for a cross-flow heat exchanger having modular profilings for the practice of the method according to any of claims 1 - 6, characterised in that the wall thickness of the plate element (30) is from 0.5 to 1.1 mm, the depth of impression of the profilings (32) is from 3.2 to 7.0 mm and the length of impression of the profilings (32) is from 10 to 20 mm.

8. A plate element according to claim 7, characterised in that the roll seams (9) opposite one another and the transverse seams (10) correspond in their widths to the widths of the plate elements (30) to be joined together, the widths preferably being of from 2 to 4 mm corresponding to a plate element width of from 250 to 400 mm.

9. A method of producing welded plate heat exchangers, substantially as hereinbefore described with reference to the accompanying drawings.